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INVESTIGATION OF AL 5383 COMPOSITE WITH AL_2O_3 AND GRAPHITE FOR MARINE APPLICATIONS

VIGNESH. C & VELAVAN. R

Assistant Professor, Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India

ABSTRACT

Aluminum alloy generally used in the industrial process to control metal dissolution especially in wear properties, Most of the efficient materials used in industry are the aluminum which is considered as the Alloy cost strength wear and corrosion also high, several researchers have made an attempt to study the inhibiting action of various alloy compounds on the corrosion and are of aluminum its alloys. So in this paper, the combination of Al 5383 with Al_2O_3 and Graphite is investigated for the better wear properties and good corrosion resistance for marine applications.

KEYWORDS: Al 5383 Composite, Al_2O_3, Graphite, Aluminum Alloy & Aluminum in Marine Application

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Original Article

INTRODUCTION

The aluminum 5383 series is mostly used in marine and aerospace application. It has high corrosion resistance, exceptional formability and welding characteristics. Because of the low strength of the alloy and low wear resistance in this series acts as a drag to use in most of the applications, so to increase the wear resistance and reduce the corrosion rate by using the combination Al_20_3 and graphite. A different ratio of aluminum 5083 alloy and graphite (MMC), by this we get the good result in a ratio of Al 89-91%, Al_20_33-4% and Gr6-8% for getting high wear resistance and corrosion resistance [1,2].

MATERIAL SELECTION

Aluminum 5383 alloy is a versatile engineering material that has a huge global market aluminum alloys are widely used in building and architecture packaging, transport, and electrical conductors. Aluminum 5383 alloy is a wrought alloy type with improved corrosion resistance and increased fatigue strength [3]. Weldability and formability of this alloy are easy using conventional methods. The succeeding datasheet will deliver more information's about aluminum 5383 alloy. Aluminum 5383 is a wrought alloy has high fatigue strength and is easily weldable and formable using conventional methods [4].

Figure 1: Aluminum 5383 Alloy

CHEMICAL COMPOSITION OF ALUMINUM 5383 ALLOY

Table 1: Chemical Composition of Aluminum 5383 Alloy

Material	Percentage
Aluminum (Al)	*91.9% to 95.3%*
Magnesium (Mg)	*4 to 5.3%*
Manganese (Mn)	*0. 7% to 1%*
Zinc (Zn)	*≤ 0. 40%*
Silicon (Si)	*≤ 0.25%*
Iron (Fe)	*≤ 0.25%*
Chromium (Cr)	*≤ 0.25%*
Copper (Cu)	*≤ 0.20%*
Titanium (Ti)	*≤ 0.20%*
Remainder	*≤ 0. 15%*

PROPERTIES OF ALUMINUM 5383

Some Mechanical and thermal properties of Aluminum 5383 alloy are charted below.

Table 2: Properties of Aluminum 5383

Properties	Metric
Tensile Strength	305×10^6 N/m^2
Yield Strength	220×10^6 N/m^2
Elongation (Break)	12 %
Shear Modulus	26.3×10^9 N/m^2
Poisson's ratio	0.32-0.34
Brinell Hardness	90 BHN
Fatigue Strength	170×10^6 N/m^2
Density	2660 Kg/m^3
Melting Point	530-640^{0}C
Thermal Expansion Coefficient	22.4×10^{-6} / ^{0}C

PROPERTIES OF ALUMINIUM OXIDE

Aluminum oxide is also called as alumina It Is a white crystalline powder with a chemical formula of Al_20_3.Aluminum oxide is taken in nature having the various minerals like bauxite and corundum. It is most cost- effective and most used in engineering ceramics.[5,6] Alumina is in the crystalline structure. The raw material is readily available and at low cost. Some important properties of Al_20_3 are listed below.

Table 3: Properties of Aluminum Oxide

Properties	Metric
Tensile Strength	329×10^6 N/m^2
Yield Strength	300×10^6 N/m^2
Elastic Modulus	$310\ 10^9$ N/m^2
Poisson's ratio	0.2 – 0.22
Bulk Modulus	$155\ 10^9$ N/m^2
Flexural Strength	330×10^6 N/m^2
Density	3690 Kg/m^3
Color	White
Porosity	0

PROPERTIES OF GRAPHITE

Aluminum alloy-Graphite composite exhibits its potential to act as a lubricating material with improved resistance to wear, machinability etc. This helps in reducing the friction and wear and postpones the onset of severe wear aluminum alloy-graphite act as a self-lubricating property [7,8].

Table 4: Properties of Graphite

Properties	Metric
Flexural Strength	7-850 x 10^6 N/m^2
Compressive Strength	25-19010^{6}N/m^2
Modulus of Elasticity	7-14 10^6 N/m^2
Bulk Density	1250-1950 Kg/m^3
Color	Black
Porosity	0.8-51%
Thermal Expansion Coefficient	1.1-8.2 x 10^{-6} / ^{0}C

CASTING OF A MATERIAL

Aluminum 5383 alloys as the base metal because of its improved corrosion resistance and increased fatigue strength. Weldability and formability of this alloy are easy by conventional methods and the reinforcement is chosen as the Aluminum oxide and graphite [9]. The $Al_20_3$is chosen for reinforcement owing to high hardness and low coefficient of thermal expansion, high wear resistance and good mechanical properties, high -temperature strength and shock resistance. Graphite is act as a solid lubrication, high corrosion resistance and reduced coefficient of friction fragments the wear product has heat seizure resistance. So we use a different ratio of material matrix composition in this project.

Table 5: Composition of Al 5383, Al_20_3 and Graphite

Material Composition
Al5383 95% + Al_20_3 3% + Gr 2%
A15383 93% + Al_20_3 3% + Gr 4%
A15383 91% + Al_20_3 3% + Gr 6%

STIR CASTING PROCESS

Technical Specifications

Operating Voltage: 400/440V,

3 Phase and AC 50 Hz

Capacity: 2Kg

Retort: Stainless steel AISI 310

Dimension of Retort: 100 mm x 300 mm (ID x Depth) Maximum

Temperature: 900^{0}C

Pouring: Motorized -Automatic

Skin Temperature: Up to 75 ^{o} C

Figure 2: Stir Casting Machine

To manufacturing the composite material by using the stir casting method the operation parameter is a very important thing. There are various processes and parameters are involved in the stir casting method. It should be controlled properly to improve the characteristic of the composite material the following is the main parameters should be taken into account while stir casting process.

- Stirring Speed (250 – 50 rpm)
- Stirring Temperature (650^0C)
- Reinforcement Preheat Temperature(500^0C)
- Stirring time (30 minutes)

  Blade angle (45^0-50^0)

Figure 3: A15383 91% + Al_20_3 3% + Gr 6% for Testing

TESTING OF A MATERIAL

ROCKWELL HARDNESS TESTING

The Rockwell hardness test results is shown in below tabulation

Table 6: Rockwell Hardness Test Results

Specimen	Load (Kgf)	Indenter	Trial-I HRB	Trial-II HRB	Average HRB
Al95%,Al_20_33%,Gr2%	100	1/16” Ball	20	21	20.5
Al93%,Al_20_33%,Gr4%	100	1/16” Ball	17	20	18.5
Al91%5Al_20_33%5Gr6%	100	1/16” Ball	17.5	25	21.5

IMPACT TESTING (CHARPY)

The Impact test (charpy) results is shown in below tabulation.

Table 7: Impact Test Results

Specimen	Area mm^2	Frictional Energy (J)	Energy Spent in Breaking (J)	Energy Absorbed (J)
Al95%,Al_20_33%,Gr2%	10x4	4	12	8
Al93%,Al_20_33%,Gr4%	10x4	4	8	4
Al91%,Al_20_33%,Gr6%	10x4	4	16	12

Calculation

Impact strength = E/A = 8/40

Al95%, Al_203_3%, Gr2% = 0.2 J/mm^2

Similarly,

Al93%, Al_203_3%, Gr4% = 0.1 J/mm^2

Al91%, Al_20_33%, Gr6% = 0.3 J/mm^2

CORROSION TEST

Nacl Corrosion Test for Composites

Initially, 5 gm of Nacl diluted with 95 ml of pure water. The total percentage of Nacl is 5%, which is diluted with 95% of composites of aluminum 5383 aluminum oxide and graphite. Then the test piece is immersed in the salt water of a one- day observation. Initially calculated the initial weight of composite and after a one day calculate the final weight of a composite material. Where we can be calculated the total weight loss percentage.

Table 8: Corrosion Test Results

Specimen	Initial weight (gm)	Time Taken in Hours			Total Weight Loss (gm)
		24	48	72	
Al95%,Al_20_33%,Gr2%	8.17	8.10	8.04	7.99	0.18
Al93%,Al_20_33%,Gr4%	8.80	8.73	8.65	8.58	0.22
Al91%,Al_20_33%,Gr6%	9.05	8.99	8.95	8.91	0.14

Calculation

Weight loss percentage = [(initial weight - Final Weight) / initial weight]* 100

Al95%, Al_203_3%, Gr2%

Weight loss percentage = [(8.17-7. 99)/8.17] * 100

Weight loss percentage =2.20%

Al93%, Al_203_3%, Gr4%

Weight loss percentage = [(8.80-8.58)/8.80] * 100

Weight loss percentage =2.5%

Al91%, Al_20_33%, Gr6%

Weight loss percentage = [(9.05-8. 91)/9.05]* 100

Weight loss percentage = 1.54%

WEAR RESISTANCE TEST

The testing result was carried out by a pin on disc machine (model TR -20). A test was conducted by the air. The wear anal sis was conducted by using the cylindrical samples which were a flat surface in the contact region and round corner. The temperature was maintained at normal at the time the wear test was conducted for the various Specimens. The pin on disc rotating disc made of N-32 steel which has the hardness of HRC66. The test was conducted by a normal load (50N, 70N,90N, 110 N) the speed of slide is 1.0 m/s. The wear test was carried out the slide distance of lkm in this process the tangential force was continuously observed. At the Time the pin weight was lost due to wear. Wear of the specimen have been measured at the interval of 10minutes and the results are obtained.

The test gave the result of wear and friction by using of a pin on disc and the conducted for all three variations. The flat end edpin specimen was used for all the specimens. The maximum weight is 4 kg, radius of a pin is 5mm,the diameter of pin is the 10 mm and the height of the pin is 30mm. The counter disc used in the test which disc made hardness steel the diameter is 30mm and thickness is 10mm. The speed of rotation of the disc is 500 rpm with 5 min. The wear test was successfully conducted for all the specimens in Room temperature. The results are shown in the graph which is very useful for to analyze the various specimen result. All the specimens have some different, value due affect the friction.The friction will be act in different surface area which the ratio is purely based on the material behavior.

Figure 4: Wear Testing Machine

The specifications of pin on disc wear testing machine as shown in below tabulation

Table 8: Specifications of Pin on Disc Wear Testing Machine

Load Range	Up to 200 N
Rotational Speed	Up to 200 rpm
Frictional Force	Up to 200 N
Compound wear	Up to 1200 Mm
Wear Disc	165mm x 8 mm (Thick)
Ball Holder	Diameter 10 mm
Pin Holder	Motorized - Automatic

The wear and friction test results are shown in below tabulation

Table 9: Wear and Friction Test Results

Specimen	Speed (rpm)	Load (Kg)	Time (minutes)	Frictional Force (N)	Wear (mm)
Al95%,Al_20_33%,Gr2%	400	4	2	11.7	154
Al93%,Al_20_33%,Gr4%	400	4	2	13.0	351
Al91%,Al_20_33%,Gr6%	400	4	2	11.5	484

RESULTS AND DISCUSSIONS

The three variations of aluminum 5383 composites with Al_20_3 and Graphite has been made and the results are obtained for the Rockwell hardness test, impact test, corrosion test and wear test are done. The results are compared with the other two variations for the best selection. The following are some graphs obtained from the wear test plotted for Time vs wear, Time vs. Frictional force, and Time vs coefficient of friction.

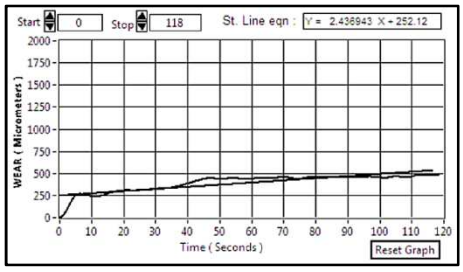

Figure 5: Time Vs Wear

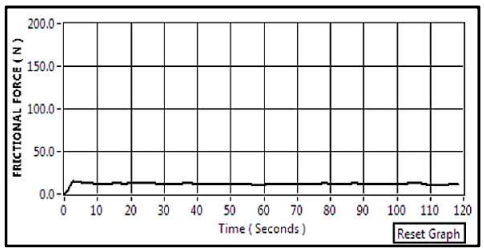

Figure 6: Time Vs Frictional Force

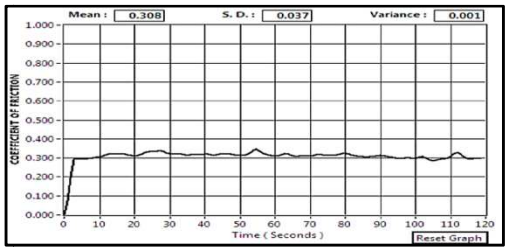

Figure 7: Time Vs Coefficient of Friction

CONCLUSIONS

In this work, we have done three different ratios of aluminum 5383 alloys with aluminum oxide and graphite was successfully fabricated by using stir casting method. We get 91 %of aluminum 5383 alloy H116 grade is mixed with 3% of aluminum oxide and added with 6% of graphite gave the successful result. Then molding is done perfectly by stir casting process and three variant materials were machined to get perfect shape for further testing. Then we done Rockwell hardness testing and get 21.5 HRB (Al 91%,Al_20_3 3%,Gr 6%). Then we did charpy impact test and get energy absorption of specimen is 0.3J/mm^2(Al 91%,Al_20_3 3%,Gr 6%). Then we done Pin on Disc test and we get wear resistance of specimen is 484 mm (Al 91%,Al_20_3 3%,Gr 6%) and friction force of a specimen is 11.5N. Then we did corrosion test by using 5% of Nacl in an observation of 72hours, in that the weight loss occurred in specimen is 1.54%. When every 3% of aluminum oxide is added with a material, the hardness increases. When a graphite is mixed with aluminum 5383 alloy to increases the corrosion resistance compare to bare aluminum. Thus the third variant with Al91%,$Al_20_3$3%,Gr6% gave a better results in all the investigations and is very suitable for marine applications where the corrosion plays an important role.

REFERENCES

1. *Sharama,Raju patel, umesh yadav "Effect of interfacial characteristics on the failure mechanism mode of a SiC reinforced A1 based metal matrix composite", Journal of Materials Processing Technology, 67(13), pp. 9499*
2. *HashimJ,LooneyL.,andHashmiM.S.J "Metal Matrix Composites: Production by the Stir Casting Method", Journal of Material Processing and Technology, 92, pp. 17.*
3. *S. Brown, "Feasibility of Replacing Structural Steel with Aluminium Alloys in the Shipbuilding Industry", University of Wisconsin-Madison, April 29, 1999.*
4. *"Corrosion of Aluminium and Aluminium Alloys", ed. by J.R.Davis & Associates, ASM Intl., Metals Park OH, USA, 1999*
5. *G.M. Raynaud, Ph. Gomiero, "Aluminium Alloys for the Marine Market", Aluminium and its Alloys, No.79, June (1996) 73*
6. *Vignesh.C,.Prasanna "Effect of constructional change in I.C engine piston by partially ceramic coating" Pakistan Journal of Biotechnology Vol. 14 special issue Pp. 116- 119 (2017)*
7. *Gyanendra Singh et al.,, Fabrication and Charecterisation of Aluminum-Graphite Composite Material, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 7, Issue 4,July- August 2017, pp. 313-320*
8. *David Raja Selvam. J, Robinson Smart. D.S. Dinaharan. "Synthesis and characterization of Al6061-Fly Ashp-SiCp composites by stir casting and compo casting methods", Elsevier & Energy Procedia 34 (2013) 637 – 646*
9. *Auradi.V., Rajesh G.L and S. A. Kori "Processing of B4C Particulate Reinforced 6061Aluminum matrix composites by melt stirring involving two-step addition" Elsevier & Procedia Materials Science 6 (2014) 1068 – 1076.*
10. *Karthe. M, Prasanna.S.C "Property evaluation of super hard alloys" Pakistan Journal of Biotechnology Vol. 14 special issue Pp. 164- 167 (2017)*
11. *Karthe. M, Prasanna.S.C "Investigations on the emission characteristics of diesel engine blende with isopropyl alcohol" Pakistan Journal of Biotechnology Vol. 14 special issue Pp. 160 - 163 (2017)*